Effect of Scrub Oak and Associated Ground cover on Soil Moisture

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About the Author . . .

ARTHUR R. ESCHNER *is a research forester on the staff of the Northeastern Forest Experiment Station's research center at Elkins, West Virginia. He has been interested in forest soils since his undergraduate days at the New York State University College of Forestry at Syracuse. He received his Master's degree at Iowa State College in 1952 and has worked since then for the U.S. Forest Service at its Central States Forest Experiment Station and at the Northeastern Station's research center at Kingston, Pa., where this study was made.*

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A Question in Planting

PLANTING experiments have been conducted for the past 10 years in the scrub oak type at the Delaware-Lehigh Experimental Forest in eastern Pennsylvania. The object of these experiments is to find a practical method of establishing a high forest of greater value than the area's present cover. In the course of these studies it was suggested that soil moisture might be a limiting factor in seedling survival and growth; so a study was made to determine soil-moisture conditions under the components of the scrub oak stand.

The scrub oak type extends over a large area of eastern Pennsylvania. It is a temporary type that became established as a result of, and is maintained by, repeated fires. It consists of a mixture of low growing shrubs and tree sprouts; primarily scrub oak *(Quercus ilicifolia,* Wangenh), sheep laurel *(Kalmia angustifolia, L.)* huckleberry *(Gaylussacia* spp. Hbk.*)*, and blueberry *(Vaccinium* spp. L.); and includes American chestnut *(Castanea dentata* (Marsh.) Borkh.), sassafras *(Sassafras albidum* (Nutt.) Nees), red maple *(Acer rubrum* L.*)*, northern red oak *(Quercus rubra* L.*)*, white oak *(Quercus alba* L.*)* and pitch pine *(Pinus rigida* Mill.). Bracken fern *(Pteridium aquilinium* (L.) Kuhn) is a commom member of the community.

The soil on which this study was made is Hazleton stony loam. This is a deep, well-drained, weakly podzolized soil developed on parent materials derived principally from fine-grained sandstones or siltstones. The surface layer of the soil is a black greasy mor. Average depth of this humus layer is 1 inch with a range from 1/2 to 2 inches. It contains considerable charcoal, and is held together by roots of the ericaceous vegetation, which have grown through it in great numbers.

It has long been recognized that the establishment and growth of tree seedlings on well-drained upland soils are directly related to available soil moisture (Toumey and Kienholz, 1931). One of the chief reasons for site preparation is to increase soil moisture for planted seedlings by reducing competition of indigenous vegetation (Toumey and Korstian, 1948, p. 232). On the Delaware-Lehigh Forest, McNamara and Reigner (1955) found that planted red and pitch pine seedlings grew best in bulldozed furrows and poorest between scrub oak clumps where the ericaceous groundcover has not been removed.

This study was designed to determine the amounts of soil moisture present under five cover conditions: (1) undisturbed humus, (2) ericaceous groundcover, (3) scrub oak, (4) scrub oak and groundcover (control), and (5) bare mineral soil.

Study Methods

Study Area

Four plots, 28 x 32 feet, were staked out in a 1/5-acre area of undisturbed vegetation and soil at the Delaware-Lehigh Forest in the spring of 1957. A fifth plot consisting of 12 root-raked scalps, each with about 10 x 14 feet of exposed soil, was located nearby.

Plots were as close together as possible to reduce variation in soil condition. Each plot was divided into three subplots; all were sampled at every sampling time.

Plot 1 (undisturbed humus) was prepared by spraying a dense cover of sheep laurel and blueberry with 2,4,5-T in oil in late May. The humus layer was not disturbed.

For the groundcover plot (Plot 2), an area with a dense cover of sheep laurel and blueberry was selected. Scattered scrub oaks and taller growing shrubs which were found only

on the edges of the plot were cut. This type of groundcover occurs naturally on a considerable area of the Experimental Forest.

The scrub oak plot (Plot 3) was one with a dense scrub oak cover. Groundcover was sprayed with 2,4,5-T in oil. The vegetation close to the scrub oak clumps was clipped and the stubs were sprayed carefully. Despite these precautions, the scrub oak crowns were damaged by the spray, and by July 15 most of the leaves had wilted and turned brown. Therefore, the results from this plot are not a true indication of the soil-moisture relations under a scrub oak stand. For the last half of the period, they more nearly approximate the soil moisture under deadened vegetation giving a high, light shade. This plot will be referred to as the scrub oak plot, but it must be understood that the damaged plot probably did not function as a healthy scrub oak stand.

The control plot (Plot 4) had an even overstory of scrub oak and a fairly dense groundcover.

Exposed soil of Plot 5 resulted from scalping by a D-6 Caterpillar tractor with a Fleco root-rake in the fall of 1956. In this treatment, which had been applied to areas to be planted to various conifers, all the humus and an average of 7.5 inches of mineral soil were removed. In addition, there was some soil disturbance to a depth of 4 to 6 inches below the new soil surface.

Sampling

Samples were taken in the mineral soil at 6-inch increments of depth down to 18 inches by means of a King tube or soil auger. Humus samples, approximately 4 inches in diameter, were taken with a trowel. Three samples, one from each subplot, were taken in each plot at weekly intervals from late spring into early fall; the last samples were taken after soil-moisture recharge was estimated to be complete. These weekly samples--29 in all--were taken at points 2 feet apart. Sampling was done systematically, beginning at a point 6 feet in from the plot edges at the southeast corner of the vegetated plots, and 3 feet in from the edges of the scalps. Sampling was not random because it was feared that walking over the extremely sensitive vegetation might damage the groundcover and reduce its transpiration.

Soil-moisture content of the samples was determined by obtaining the moisture loss on drying and the weight of the oven-dry, stone-free soil. Because stones contributed a weight far out of proportion to their water-holding capacity, they

were removed after drying by passing the sample through a 2-millimeter mesh screen. The stones were then weighed and their weight was deducted from the gross oven-dry weight of the soil.

This procedure did not permit an exact estimate of that part of the weight loss on drying contributed by the stones' moisture content. However, a simple supporting study on the moisture content of stones from saturated soil showed that their maximum moisture content was 3.7 percent by weight; air-dry they held 2.4 percent. Largest stones picked up by a King tube, those between 0.5 and 1 inch in the longest dimension, had a lower moisture content than smaller stones. And any sample with an appreciable stone content had one or more of these larger stones.

Stone content for subplot samples varied from 0.5 to 33.6 percent of the gross oven-dry weight of soil and stones. When the three subsamples from the plot were pooled, values for stones varied between 2.4 and 11.1 percent, with the average stone content for the entire study about 7 percent. The increase in inches of water for a 6-inch layer, determined by using the stone-free soil instead of the natural stony soil, ranged from 4 to 12 percent. Because of the generally low stone-moisture content and its undetermined variability, no correction was made for this factor.

Bulk-density samples in triplicate were obtained at two locations: one in the undisturbed soil representing the vegetated plots, the other in the root-raked scalps. Average bulk-density values, in grams per cubic centimeter, were as follows:

Depth (inches)	*Vegetated plots (grams)*	*Scalped plot (grams)*
Humus	0.28	--
0 to 6	1.13	1.46
6 to 12	1.14	1.76
12 to 18	1.60	1.83

These values were determined on soil that was essentially free of stones. Cores in which stones were discovered after drying were discarded and new samples collected. A sampler of the type described by Coile (1936) was used to obtain the undisturbed cores.

Estimates of the rock content of the three depths in mineral soil were obtained at five locations for the vegetated plots and two locations in the scalps. The weight of any rock over 1 inch in the longest dimension in each 6-inch layer of soil was obtained.

Also, the number of inches of depth of rock in the layer was computed, assuming a specific gravity of 2.65 for the rocks.

Analysis

Soil moisture in inches of water for the stone-free soil was computed from the samples in the following manner:

$$\text{Soil moisture (inches of water)} = \frac{\text{(moisture percent by weight)}}{100} \times \text{(bulk density)} \times \text{(inches of soil depth - inches of rock)}$$

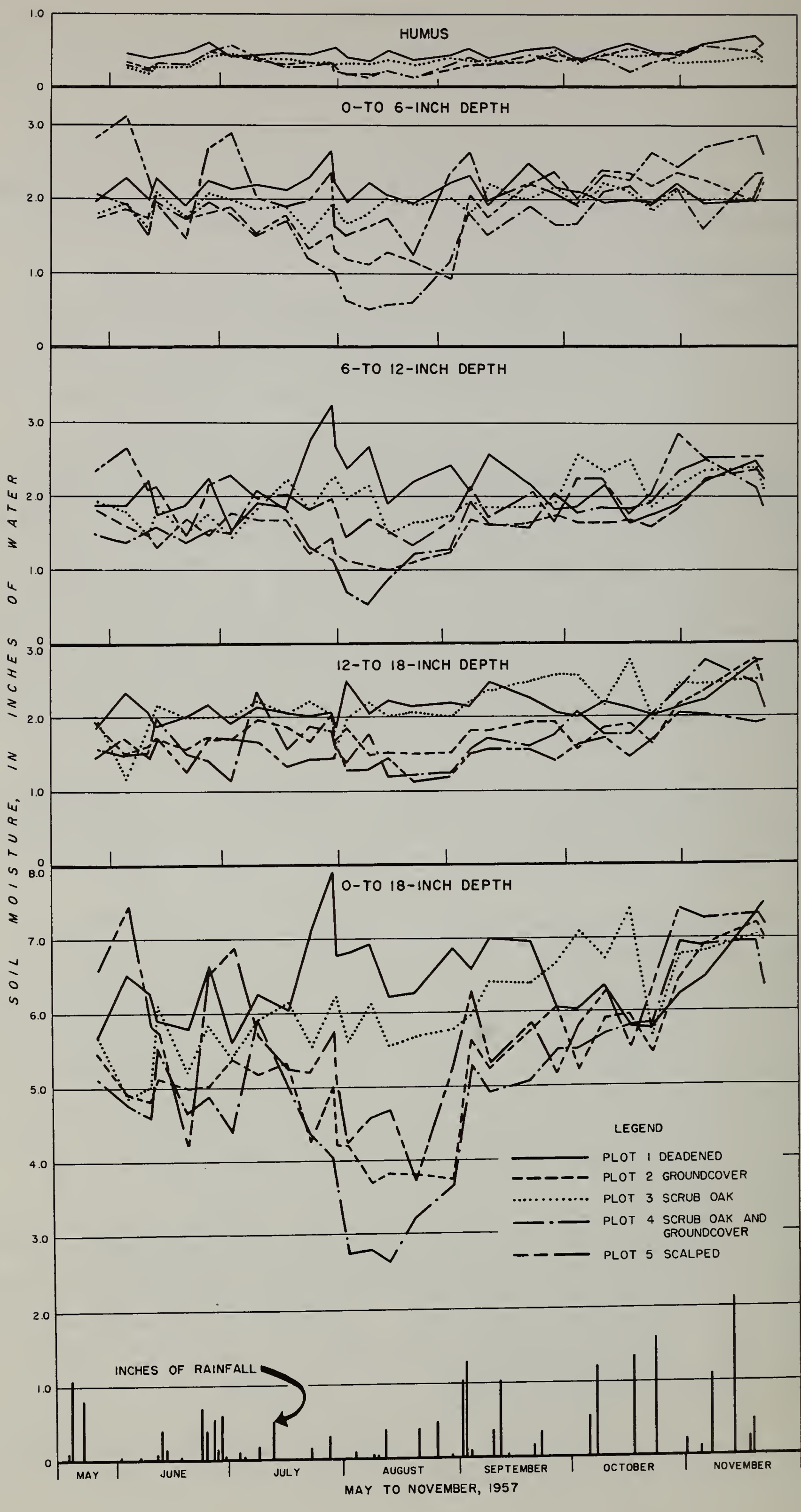
In order to obtain comparable values for use in analysis, a series of four complete samples was taken in the summer and fall of 1957 when the soil was considered to be at or slightly above field capacity. Values of each treated plot were compared with those from Plot 4, the control. (Control-plot values agreed closely with those obtained over an 8-year period from a nearby stack of fiberglas soil-moisture units). Where field capacities varied more than 0.10 inch from those of the control plot, they were adjusted to that level and the remaining samples were adjusted proportionately. Adjusted values are shown in figure 1.

Rainfall for the period of the study is also shown in figure 1. These data are from a recording rain gage located 200 yards from the site of the study.

Analyses of variance of the inches of water in the mineral soil samples were computed for four periods: (1) the total period of the study, May 27 to November 22; (2) an early period of active growth and soil-moisture depletion, May 27 to August 13; (3) a late period of vegetation dormancy and soil-moisture recharge, August 20 to November 22; and (4) a period, overlapping the previous two, during a severe summer drought, July 17 to August 29. Rainfall during this drought period was 1.94 inches, less than one-third of the 6-year average of 6.88 inches.

The mean soil-moisture contents for the four periods and five plots are summarized in tables 1 through 4. In these tables, all possible differences among the indicated plot means are also presented. The "least significant differences" were computed according to Hartley's method as reviewed by Snedecor (1956).

Parallel analyses of variance and "least significant differences" were computed for the humus layer. The mean humus-



HUMUS
0-TO 6-INCH DEPTH
6-TO 12-INCH DEPTH
12-TO 18-INCH DEPTH
0-TO 18-INCH DEPTH
SOIL MOISTURE, IN INCHES OF WATER
LEGEND
PLOT 1 DEADENED
PLOT 2 GROUNDCOVER
PLOT 3 SCRUB OAK
PLOT 4 SCRUB OAK AND GROUNDCOVER
PLOT 5 SCALPED
INCHES OF RAINFALL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
MAY TO NOVEMBER, 1957

moisture contents for the four periods and four plots are given in table 5. Because of the variation in depth of the humus samples, inches depth of water was not analyzed. The value analyzed was percent of moisture by volume, transformed to the angle whose sine is the square root of the percentage. This is the arcsin transformation discussed by Snedecor (1956).

Results & Discussion

The graphs (fig. 1) of soil-moisture content over time indicate differences in the amounts of water held in the soil under different vegetative covers at different depths.

F-tests of the analyses of variance of soil moisture contents, at each depth, under the various covers and during the four previously described periods, showed that there were differences among the plots, significant at the 1-percent level. Least significant differences were calculated from the analyses. Comparison with the differences between mean moisture contents, as given in tables 1 through 4, showed which of these were significant.

The results of these analyses have a reasonable physical explanation and are fairly consistent. They showed that soil under ericaceous groundcover was driest throughout the growing season, indicating that this low-growing vegetation is the major user of soil moisture in the scrub oak type of eastern Pennsylvania. However, this conclusion has not been firmly established by this study. There was not a good comparison with the water use of the scrub oak, and it is probable that the groundcover did not remove as much moisture from the soil on the control plot, where it was competing with the scrub oak, as it did where it was not.

During the growing season and drought period there were some differences between the scrub oak plot (Plot 3) and the deadened plot (Plot 1), which indicated the scrub oak was still actively transpiring. Therefore, in spite of the plot's damaged condition, the data from the scrub oak plot was retained in the analyses. In the recharge period, it reacted like the deadened plot.

'igure 1.--Soil moisture content and rainfall,
lay to November 1957.

Table 1.--Mean soil-moisture contents and differences between plots, by cover type, for the total sampling period, May 27 to November 22, 1957

Plot No.	Cover	Inches of water				
		Mean	Differences			
			Ground-cover	Scrub oak	Control	Bare
		0- to 18-INCH DEPTH				
1	Humus	6.48	-1.24*	-0.36	-1.55*	-0.67*
2	Groundcover	5.24	--	+ .88*	- .31	+ .57*
3	Scrub oak	6.12	--	--	-1.19*	- .31
4	Control	4.93	--	--	--	+ .88*
5	Bare	5.81	--	--	--	--
		0- to 6-INCH DEPTH				
1	Humus	2.15	-0.35*	-0.19*	-0.56*	+0.07
2	Groundcover	1.80	--	+ .16	- .21*	+ .42*
3	Scrub oak	1.96	--	--	- .37*	+ .26*
4	Control	1.59	--	--	--	+ .63*
5	Bare	2.22	--	--	--	--
		6- to 12-INCH DEPTH				
1	Humus	2.16	-0.56*	-0.20	-0.58*	-0.13
2	Groundcover	1.60	--	+ .36*	- .02	+ .43*
3	Scrub oak	1.96	--	--	- .38*	+ .07
4	Control	1.58	--	--	--	+ .45*
5	Bare	2.03	--	--	--	--
		12- to 18-INCH DEPTH				
1	Humus	2.17	-0.34*	+0.03	-0.42*	-0.61*
2	Groundcover	1.83	--	+ .37*	- .08	- .27*
3	Scrub oak	2.20	--	--	- .45*	- .64*
4	Control	1.75	--	--	--	- .19*
5	Bare	1.56	--	--	--	--

*Significant at the 5-percent level.

Table 2.--Mean soil-moisture contents and differences between plots, by cover types, for the growing season, May 27 to August 13, 1957

Plot No.	Cover	Inches of water				
		Mean	Differences			
			Ground-cover	Scrub oak	Control	Bare
		0- to 18-INCH DEPTH				
1	Humus	6.43	-1.67*	-0.74*	-2.09*	-0.85*
2	Groundcover	4.76	--	+ .93*	- .42	+ .82*
3	Scrub oak	5.69	--	--	-1.35*	- .11
4	Control	4.34	--	--	--	+1.24*
5	Bare	5.58	--	--	--	--
		0- to 6-INCH DEPTH				
1	Humus	2.16	-0.57*	-0.30*	-0.76*	-0.04
2	Groundcover	1.59	--	+ .27*	- .19	+ .53*
3	Scrub oak	1.86	--	--	- .46*	+ .26*
4	Control	1.40	--	--	--	+ .72*
5	Bare	2.12	--	--	--	--
		6- to 12-INCH DEPTH				
1	Humus	2.19	-0.74*	-0.36*	-0.87*	-0.24
2	Groundcover	1.45	--	+ .38*	- .13	+ .50*
3	Scrub oak	1.83	--	--	- .51*	+ .12
4	Control	1.32	--	--	--	+ .63*
5	Bare	1.95	--	--	--	--
		12- to 18-INCH DEPTH				
1	Humus	2.08	-0.36*	-0.08	-0.46*	-0.58*
2	Groundcover	1.72	--	+ .28*	- .10	- .22*
3	Scrub oak	2.00	--	--	- .38*	- .50*
4	Control	1.62	--	--	--	- .12
5	Bare	1.50	--	--	--	--

*Significant at the 5-percent level.

Table 3.--Mean soil-moisture contents and differences between plots, by cover types, for the dormant period, August 20 to November 22, 1957

Plot No.	Cover	Inches of water				
		Mean	Differences			
			Ground-cover	Scrub oak	Control	Bare
		0- to 18-INCH DEPTH				
1	Humus	6.52	-0.77*	+0.06	-0.96*	-0.46
2	Groundcover	5.75	--	+ .83*	- .19	+ .31
3	Scrub oak	6.58	--	--	-1.02*	- .52
4	Control	5.56	--	--	--	+ .50
5	Bare	6.06	--	--	--	--
		0- to 6-INCH DEPTH				
1	Humus	2.13	-0.10	-0.07	-0.33*	+0.19
2	Groundcover	2.03	--	+ .03	- .23	+ .29
3	Scrub oak	2.06	--	--	- .26	+ .26
4	Control	1.80	--	--	--	+ .52
5	Bare	2.32	--	--	--	--
		6- to 12-INCH DEPTH				
1	Humus	2.14	-0.37*	-0.05	-0.28*	-0.03
2	Groundcover	1.77	--	+ .32*	+ .09	+ .34*
3	Scrub oak	2.09	--	--	- .23*	+ .02
4	Control	1.86	--	--	--	+ .25*
5	Bare	2.11	--	--	--	--
		12- to 18-INCH DEPTH				
1	Humus	2.26	-0.31*	+0.16	-0.36*	-0.62*
2	Groundcover	1.95	--	+ .47*	- .05	- .31*
3	Scrub oak	2.42	--	--	- .52*	- .78*
4	Control	1.90	--	--	--	- .26*
5	Bare	1.64	--	--	--	--

*Significant at the 5-percent level.

Table 4.--Mean soil-moisture contents and differences between plots, by cover types, for the drought period, July 17 to August 29, 1957

Plot No.	Cover	Inches of water					
		Mean	Differences				
			Ground-cover	Scrub oak	Control	Bare	
		0- to 18-INCH DEPTH					
1	Humus	6.77	-2.54*	-0.91*	-3.20*	-1.91*	
2	Groundcover	4.23	--	+1.63*	- .66*	+ .63*	
3	Scrub oak	5.86	--	--	-2.29*	-1.00*	
4	Control	3.57	--	--	--	+1.29*	
5	Bare	4.86	--	--	--	--	
		0- to 6-INCH DEPTH					
1	Humus	2.18	-0.89*	-0.32*	-1.26*	-0.37*	
2	Groundcover	1.29	--	+ .57*	- .37*	+ .52*	
3	Scrub oak	1.86	--	--	- .94*	- .05	
4	Control	0.92	--	--	--	+ .89*	
5	Bare	1.81	--	--	--	--	
		6- to 12-INCH DEPTH					
1	Humus	2.46	-1.21*	-0.53*	-1.36*	-0.76*	
2	Groundcover	1.25	--	+ .68*	- .15	+ .45*	
3	Scrub oak	1.93	--	--	- .83*	- .23*	
4	Control	1.10	--	--	--	+ .60*	
5	Bare	1.70	--	--	--	--	
		12- to 18-INCH DEPTH					
1	Humus	2.13	-0.45*	-0.06	-0.61*	-0.78*	
2	Groundcover	1.68	--	+ .39*	- .16	- .33*	
3	Scrub oak	2.07	--	--	- .55*	- .72*	
4	Control	1.52	--	--	--	- .17	
5	Bare	1.35	--	--	--	--	

*Significant at the 5-percent level.

Table 5.--Mean humus-moisture contents and differences among plots

Plot No.	Cover	Percent by volume			
		Mean	Differences		
			Ground-cover	Scrub oak	Control
		JUNE 4 to NOV. 22, 1957			
1	Humus	36.9	- 5.4*	+ 6.3*	- 4.2*
2	Groundcover	31.5	--	+11.7*	+ 1.2
3	Scrub oak	43.2	--	--	-10.5*
4	Control	32.7	--	--	--
		JUNE 4 to AUG. 13, 1957 (GROWING SEASON)			
1	Humus	34.5	- 8.3*	+ 4.9*	- 5.7*
2	Groundcover	26.2	--	+13.2*	+ 2.6
3	Scrub oak	39.4	--	--	-10.6*
4	Control	28.8	--	--	--
		AUG. 20 to NOV. 22, 1957 (DORMANT, RECHARGE PERIOD)			
1	Humus	39.3	- 2.2	+ 7.9*	- 2.6
2	Groundcover	37.1	--	+10.1*	- 0.4
3	Scrub oak	47.2	--	--	-10.5*
4	Control	36.7	--	--	--
		JULY 17 to AUG. 29, 1957 (DROUGHT PERIOD)			
1	Humus	34.1	-13.9*	+ 6.9*	-11.4*
2	Groundcover	20.2	--	+20.8*	+ 2.5
3	Scrub oak	41.0	--	--	-18.3*
4	Control	22.7	--	--	--

*Significant at the 5-percent level.

Differences in soil moisture between plots during periods of active growth and high water use, as shown in tables 2 and 4, were greatest in the 0- to 6- and 6- to 12-inch layers. In the 12- to 18-inch layer, for these periods, differences between plots were less. This is largely a reflection of differences in root activity. Roots of the ericaceous groundcover ramify profusely through the humus layer and to some extent through the 0- to 6-inch layer. The number of roots gradually decreases with depth, until below 12 inches there is very little evidence of rooting.

The roots of scrub oak develop most profusely near the surface in the mineral soil, but strong individual roots were found at all depths sampled. This difference in rooting depth and habit was strikingly apparent following a hot fire that destroyed the humus layer. Scrub oak sprouts appeared in great profusion from old roots in the mineral soil, but the ericaceous groundcover, which sprouts as readily from its roots, did not become re-established in any appreciable density on the bare area for a year or more.

The humus plot (Plot 1) consistently showed the highest mean soil moisture of any plot or was not significantly different from the highest. It always differed significantly from the control and groundcover plots. In the 18-inch layer of soil studied, there was an average of 2.09 inches more soil moisture under deadened vegetation than under the intact scrub oak and groundcover during the growing season, and 3.20 inches more during the drought.

The control plot (Plot 4) of scrub oak and groundcover usually had the lowest mean soil moisture of any vegetated plot at all the depths sampled. The groundcover plot (Plot 2) generally had the next lowest soil moisture. Differences between these two plots were generally insignificant. However, there was a significant difference in the 0- to 6-inch depth during the drought period. (Apparent significant differences between these two plots in the 0- to 6-inch depth for the total sampling period, and in the 0- to 18-inch depth for the drought period were caused by this one difference.) This may be largely explained by the scrub oak intercepting much of the rainfall which fell in light showers during this period.

Some of the differences in soil moisture between the control and groundcover plots may be explained in part by the concentration of rainfall near the root collars of the scrub oak clumps. Interception of rainfall by the scrub oak crowns and subsequent stemflow and delivery to the soil at a point near the base of the sprout clump, a point that is practically impossible to sample, in effect reduces the amount of rainfall

over much of the scrub oak-groundcover plot as compared with a similar area having no scrub oak cover.

Moisture content of the scalped plot (Plot 5) was extremely variable, but generally maintained an intermediate rank. However, direct comparison between vegetated and scalped plots is not too meaningful because of differences in the soil layers sampled. In the scalped plots, the root rake removed an average of 7.5 inches of mineral soil in addition to the humus. This exposed the B horizon, with a bulk density in the first 6 inches of soil of 1.46 grams per cubic centimeter, compared to 1.13 on the vegetated plots. Root-raking and subsequent rains destroyed much of the soil structure and caused some sealing of the soil surface in the scalps. The uneven surface produced by the root-rake caused ponding of rainwater in some places and rapid local runoff in others. These conditions undoubtedly contributed to the variation in soil moisture in the scalped patches.

The fact that the scalped plot consistently had the lowest moisture content in the 12- to 18-inch layer is a reflection of its extremely high bulk density of 1.83 and does not indicate any appreciable root activity.

It will be noted that only the amounts of water held in the mineral soil have been included in the total depth summary. From previous observations on the rooting of planted tree seedlings, it was felt that the moisture held in the humus was not available to these plants. Their roots develop in the mineral soil just below the humus layer. However, the action of the mor humus in protecting the mineral soil from the impact of rain, in temporarily holding appreciable volumes of water, and in acting as an insulating and evaporation-inhibiting mulch is of considerable importance. Infiltration tests on wet soils in the scalps and on those with an undisturbed humus cover gave striking differences. The average length of time required for 1 inch of water to enter the soil with an intact humus layer was 36 seconds; on the scalped soil it was at least 24 minutes.

The humus layer of the scrub oak plot consistently showed the highest moisture content (table 5), always significantly higher than that of the deadened plot. Differences between these two plots in amount of moisture in the humus probably reflect differences in evaporation. The scrub oak, although damaged, gave a high, light shade for most of the period of the study. The deadened groundcover of Plot 1 soon lost its leaves and exposed the black humus layer to the direct rays of the sun. This resulted in a greater amount of evaporation from the humus in Plot 1 than from that under the scrub oak.

There was no significant difference between the humus moisture content of the groundcover and control plots.

Results of this study indicate that for best soil-moisture conditions for planted conifers in the scrub oak type, the scrub oak and groundcover should be deadened and the humus layer should not be disturbed. A treatment that deadens the scrub oak alone cannot be expected to reduce transpiration a significant amount.

Summary

Soil moisture was sampled in Hazleton stony loam in eastern Pennsylvania on 29 dates in the summer and fall of 1957. Sampled during this period were three depths--0 to 6 inches, 6 to 12 inches, and 12 to 18 inches--and five cover types--bare, groundcover, scrub oak and groundcover, scrub oak, and undisturbed humus with deadened cover.

Significant differences were found in the amounts of water held in the soil under various cover conditions. Soil moisture was consistently highest on areas where the cover had been deadened, and lowest under a mixed cover of scrub oak and ericaceous groundcover. In an 18-inch layer of soil, there was an average of 2.09 inches more soil moisture under the deadened vegetation than under the intact scrub oak and groundcover during the growing season, and 3.20 inches more during a drought. An area covered chiefly by sheep laurel generally had the second lowest soil-moisture content.

During a severe summer drought, differences between the two plots having the lowest soil-moisture contents were not significant except in the 0- to 6- and 12- to 18-inch layers. These differences are attributed chiefly to differences in root activity, but may be explained in part by the concentration of rainfall around scrub oak sprout clumps, caused by interception and stemflow. This gives higher soil-moisture contents to areas that are difficult to sample gravimetrically at the expense of areas that are more likely to be sampled. Thus the measured soil-moisture content for the plot may be lower than the actual, but undetermined, soil-moisture content.

The soil-moisture content of the bare area from which the natural humus layer and several inches of topsoil had been removed was generally intermediate in rank. The consistently

lower soil-moisture content in the 12- to 18-inch layer reflects its high bulk density.

A site treatment that completely deadens the low-growing vegetation but does not destroy the humus layer should be the most desirable for making maximum amounts of soil moisture available to planted seedlings. Deadening the scrub oak alone will not reduce transpiration losses any appreciable amount.

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